Modelling Applied to Vegetable Production

Module on Pathogens and Parasites

Dr Giorgia Fedele

COURSE AIMS AND INTENDED LEARNING OUTCOMES

The course aims to provide students with the knowledge and skills necessary to understand how plant diseases develop and how to create and employ mathematical models in the sustainable and precision protection of crops.

At the end of the course, students will be able to understand how mathematical models are created for the development of diseases in relation to the environmental and cultural factors that influence them, how they are validated, as well as the positive and negative aspects of the various modelling techniques . In particular, students will have the skills to analyse the literature and independently collect the information and data necessary to develop mathematical models for the prediction of diseases, their validation and phytoiatric use. Students will also be able to critically harness this knowledge and use models in developing precision crop protection strategies and tactics.

Students will develop the ability to independently process and critically analyse current knowledge using a multidisciplinary approach, so as to be able to face and solve new and/or unexpected problems. Students will also be able to communicate what they have learned in a clear, comprehensive and unequivocal way to their interlocutors.

COURSE CONTENT

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| --- | --- |
| Teaching chapter | ECTS |
| Basic elements of phytopathological modelling. Analysis of epidemics, processes and temporal and spatial dynamics. Dynamic simulation of epidemics Notes on modelling applied to phytophages. | 1 |
| Empirical models; development techniques; pros and cons of empirical models. | 0.5 |
| Process models; model development; use of systems analysis; statistical techniques and methods for model validation.  | 1.5 |
| Tutorials: modelling and simulation of systems using the STELLA® software; systematic literature research; group work. | 1 |

READING LIST

R. Rabbinge, H.H. van Laar, S.A. Ward, *Simulation and Systems Management in Crop Protection* Pudoc, 1989 Volume 32; ISSN 0924-8439.

L.V. Madden-G. Hughes-F. van den Bosch, *The study of Plant Disease Epidemics,* APS Press, St. Paul, Minnesota, 2007.

Other texts and reading material will be indicated during the course.

TEACHING METHOD

* Frontal lectures in the classroom with the help of PowerPoint presentations and videos, and with time dedicated to questions and requests for clarification and/or further detail.
* Classroom tutorials with software for the development of mathematical models.
* In-depth group work.
* Seminars with experts to study specific topics of particular relevance.

ASSESSMENT METHOD AND CRITERIA

The final exam consists of a written test with 30 questions to be addressed in a maximum of 60 minutes. The questions may require, for example, open-ended, single or multiple answers, the identification of correct options in a list, or their ordering according to relative importance. The exam will be marked out of 30. The group work, assigned during the course, will be evaluated by the lecturer and used for the assignment of the final grade.

NOTES AND PREREQUISITES

Students must possess knowledge of general plant pathology.

The teaching material and any further in-depth analysis of topics will be available on the Blackboard platform.

Should the health situation relating to the Covid-19 pandemic not allow face-to-face teaching, remote teaching in synchronous or asynchronous mode will be guaranteed; this will be communicated in good time to students.

Information on office hours available on the teacher's personal page at http://docenti.unicatt.it/.

Module on Tree Cultivation

Prof. Sergio Tombesi

COURSE AIMS AND INTENDED LEARNING OUTCOMES

The course aims to provide the basic and applicative elements for the use and construction of models for arboreal plants.

Knowledge and understanding

At the end of the course, students will be able to:

* Describe the main modelling strategies for arboreal plants.
* Understand the differences between the various strategies by understanding their limitations and strengths.

Ability to apply knowledge and understanding

At the end of the course, students will be able to:

* Apply the rudiments of the different modelling techniques.
* Use the main features of the available models.

Autonomous judging skills

Faced with a specific problem, students will be able to independently analyse the unique features of the different modelling strategies and evaluate where best to apply them.

Communication skills

Students will be able to successfully communicate, both in oral and written form, a correct understanding of the different topics and explain an appropriate critical discussion, using correct and appropriate technical language.

Learning ability

Students will be able to modify their actions according to the specific elements that must be considered when choosing a modelling strategy and know how to evaluate the results.

COURSE CONTENT

|  |  |
| --- | --- |
|  | ECTS |
| Types, history and purpose of the models for arboreal plants | 1.0 |
| Evolution of modelling applied to arboreal plants, empirical models, process-based plant models, functional-structural plant models. |  |
| Structural modelling strategies | 0.5 |
| Plant architecture modelling, methodologies and examples. |  |
| Functional modelling strategies | 1.0 |
| Microclimate, phenology, primary metabolism, C division, hydraulics. |  |
| Forestry models | 0.5 |
| Purposes, principles of allometry, forestry techniques and their modelling. |  |
| Practical tutorials  | 1.0 |

READING LIST

DeJong TM, 2021, Concepts for understanding fruit trees, CABI concise pp 152

J. Vos, LFM Marcelis, PHB de Visser, PC Struik and JB Evers (Eds.), Functional-Structural Plant Modelling in Crop Production

Lecture notes.

TEACHING METHOD

The teaching method will include the following activities:

1) frontal lectures in which the main course topics will be addressed, together with various applied examples. The teaching strategy aims to achieve a high degree of interaction between the lecturer and the students in order to stimulate discussion and break through any barriers of shyness.

2) Practical activities and internal or external (i.e. in the field) tutorials aimed at understanding the methodologies for modelling plant architecture.

3) Group work on specific case studies aimed at analysing different modelling strategies for arboreal plants.

ASSESSMENT METHOD AND CRITERIA

Final oral exam. Three main questions will be posed during the exam, which will give rise to a discussion on more specific concepts. Each of these questions carries a mark of 10/30. The mark is assigned on the basis of the following criteria: a) objective knowledge of the topics and mastery of the subjects (5 marks); b) clarity of presentation (2 marks); c) ability to respond exhaustively to questions linking different topics (3 marks).

The first question is aimed at ascertaining the student's understanding of the different types of models available. The second question involves a description of the structural and functional modelling techniques. The third question concerns the application and use of the models.

NOTES AND PREREQUISITES

Students must possess a basic knowledge of the topics of botany, biochemistry, plant physiology, arboriculture, mathematics and computer science.

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Module on Herbaceous Crops

Prof. Stefano Amaducci

COURSE AIMS AND INTENDED LEARNING OUTCOMES

The course aims to provide students with the theoretical and practical tools for using herbaceous crop simulation models. The modelling of biophysical systems in agriculture provides a systematic and powerful approach to tackling the study of crop ecophysiology, and a quantitative and mechanistic understanding of the relationships and interactions between crops and production factors. The course critically addresses biophysical phenomena in agriculture, and the mathematical tools for simulating the effects of soil, weather, agricultural management (farmer's choices) and genetic factors on the production of herbaceous crops. Different approaches for simulating crop growth and development, water use, nutrient absorption and carbon dynamics are presented. After providing the basic elements of modelling, the course deals with the study of procedures and tools for decision support (DSS), the analysis of alternative agronomic choices, and the collection and management of data. Finally, using calculation platforms, practical simulation tests will be carried out to support precision agriculture, integrating the use of satellite data and real-time calibration of crop growth and development.

INTENDED LEARNING OUTCOMES

Knowledge and ability to understand

At the end of the course, students will be able to:

* Understand the fundamental concepts behind simulating the growth and production of herbaceous crops;
* Know the main functions and usage potential of the models in agriculture;
* Know and understand the main state variables and guide variables of the simulation models;
* Know the meaning of calibration and validation of growth models;
* Know the main statistics for evaluating the reliability of a simulation model.

Understanding and applying knowledge

At the end of the course, students will be able to:

* Carry out simulations using an IT platform presented during the course;
* Modify the simulation parameters to simulate the effect of cultivation techniques on crop growth and production;
* Perform a critical analysis of the outputs of a simulation model.

Autonomous judging skills

At the end of the course, students will be able to:

* Evaluate the problems and potentials related to the use of simulation models for the management of herbaceous crops.

Communication skills

At the end of the course, students will be able to:

* Appropriately use the scientific language and specific vocabulary of herbaceous crop mathematical simulations;
* Tackle technical discussions related to herbaceous crop simulation.

Learning ability

At the end of the course, students will be able to:

* Extend their acquired knowledge on herbaceous crop simulation through the consultation of dedicated texts and scientific journals, even beyond the aspects covered in class.

COURSE CONTENT

|  |  |
| --- | --- |
|  | ECTS |
| Introduction to the course.The importance of models in agriculture.Core concepts- What is a model?- Main mathematical techniques for representing the evolution of a biological system in time and space.- State variables.- Guide variables.- Overview of the use of models in agriculture. | 0.5 |
| Radiation- Radiation balance.- Light interception and photosynthesis.- Simulation of soil water dynamics and crop response.- Analysis of crop water requirements and irrigation water productivity. Influence of climate, soil properties and agrotechnics.- Simulation of nitrogen and carbon dynamics in soil and crop responses. | 2.5 |
| Tutorials- Use of Excel for the calculation of thermal sums and phenological development;- Use of Excel to estimate evapotranspiration;- Installation and use of a model to simulate the effects of strategic and tactical choices on production and environmental impact;- Use of an IT platform to integrate remote sensing data and simulation models. | 1.0 |

READING LIST

Afshin Soltani &Thomas R. Sinclair. Modelling physiology of crop development, growth and yield. CAB International 2012.

Further materials for in-depth study, together with the slides presented in class, will be provided during the course.

TEACHING METHOD

Theoretical frontal lectures, in which the main topics of the course will be addressed.

The tutorials will be dedicated to the use of IT tools for simulating the growth and production of the main herbaceous species of agricultural interest.

The lectures will be held with the aid of PowerPoint presentations provided to the students before the lesson.

At the end of each course topic, a series of questions and sample exam questions will be presented.

ASSESSMENT METHOD AND CRITERIA

Final oral assessment, preceded by a practical test of the student's use of the IT tools used during tutorials.

The oral exam consists of three questions, each of which carries a mark of between -10 and +10.

The exam is designed to assess primarily the student's reasoning ability and analytical rigour with respect to the course subjects, as well as their communication skills and command of the language.

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